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Docket No.: 2091-0189P

Assistant Commissioner for Patents
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Washington, D.C. 20231

Sir:

Transmitted herewith for filing is the patent application of

Inventor(s): NOGUCHI, Takafumi

For: METHOD AND SYSTEM FOR ADJUSTING IMAGE BRIGHTNESS

Enclosed are:

X A specification consisting of 14 pages

X 2 sheet(s) of Formal drawings

X An assignment of the invention

X Certified copy of Priority Document(s)

X Executed Declaration X Original ___ Photocopy

___ A verified statement to establish small entity status under 37 CFR 1.9 and 37 CFR 1.27

___ Preliminary Amendment

___ Information Disclosure Statement, PTO-1449 and reference(s)

___ Other _____

The filing fee has been calculated as shown below:

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TOTAL CLAIMS	4 - 20 =	0	x18 =$	0.00	or	x 9 = $	0.00
INDEPENDENT	2 - 3 =	0	x78 =$	0.00	or	x 39 = $	0.00
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Respectfully submitted,

BIRCH, STEWART, KOLASCH & BIRCH, LLP

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METHOD AND SYSTEM FOR ADJUSTING IMAGE BRIGHTNESS

BACKGROUND OF THE INVENTION

Field of the Invention

This invention relates to a method for adjusting image brightness at the time of reproducing an image read from photo film or an image photographed with a digital camera as a photographic print or the like and to a system for implementing the method.

Description of the Related Art

One conventional method for adjusting the brightness of an image photographed with a camera or the like is autoexposure (AE). In generally adopted AE, desirable mean picture brightness is assumed to be equivalent to 18% reflectance and the diaphragm aperture and shutter speed of the camera are controlled to make the mean picture brilliance value equivalent to 18% reflectance.

One technique used to improve the exposure accuracy is to divide the picture into multiple regions and determine the final mean brilliance taking the mean values of the individual regions or differences between regions into account (as in center-selective light measurement, valuative light measurement and the like). Some cameras, particularly sophisticated single-lens reflex cameras, enhance exposure accuracy by additionally utilizing an autofocus function to detect the main subject.

The application of such techniques is not limited to the camera side. On the lab printer side, too, it is a common practice to adjust brightness by controlling the number of seconds of exposure when exposing the print paper so as to give the large area transmittance density (LATD) of the negative a print density corresponding to 18% reflectance (i.e., a print density of 0.75).

Since these methods postulate the mean image brightness to be 18% reflectance, however, they encounter problems when, for example, the pictures includes an object of very high or low brightness. Specifically, such objects markedly affect the mean value of the brightness and, as such, cause the image obtained to be excessively light or dark.

SUMMARY OF THE INVENTION

This invention was accomplished in light of the foregoing circumstances and has as one object to provide a method for adjusting image brightness that enables the brightness of an image to be adjusted with high accuracy. Another object of the invention is to provide a system for implementing the method.

Figure 2 shows the magnitude of the color difference components, i.e., color saturations, of R, G and B (red, green and blue) and C, M and Y (cyan, magenta and yellow) hues in the CIE $L^*a^*b^*$ color representation system. (See R.W.G. Hunt, *The reproduction of colour*, 4th edition, Fountain Press (1987), p142.) The vertical axis in Figure 2 is scaled for lightness

L but, for convenience, the horizontal axis is scaled for one dimension of the two-dimensional plane of the color difference a^*b^*, so that $\sqrt{(a^{*2} + b^{*2})}$ $(= c^*)$. The point at which $L^* = 50$ in Figure 2 represents a lightness corresponding to 18% reflectance. For every hue shown in Figure 2, color saturation is highest in the vicinity of $L^* = 50$, i.e., in the vicinity of a lightness of 18% reflectance, and the color saturation is 0 at $L^* = 0$, i.e., 0% reflectance, and at $L^* = 100$, i.e., 100% reflectance. It can therefore be concluded that a pixel's lightness comes closer to 18% reflectance with increasing color saturation. This invention was accomplished with attention to this fact.

Specifically, in one aspect of the present invention there is provided a method for adjusting image brightness comprising the steps of effecting a computation on color image data represented by a color signal composed of at least three components to obtain pixel lightness components and adjusting brightness of an image represented by the color image data based on the lightness components, the method being characterized in further comprising a step of adjusting the brightness of the image represented by the color image data based on color saturation components of the pixels.

By "color signal composed of at least three components" is meant an RGB, CMY or other such color signal commonly used to represent a color image. When the values of the color signal components are identical, the eye perceives gray.

Specific "lightness components" that can be adopted include, for instance, R, G and B mean values, lightness components based on brilliance, and lightness components that are, for example, the maximum values among the R, G and B values. The present invention is, however, not limited to these lightness components.

The "color saturation components" that can be adopted include, for instance, the ratios or the like between the R, G and B maximum and minimum values. The present invention is, however, not limited to these color saturation components.

In the method for adjusting image brightness according to the present invention, it is preferable to compute weighted lightness components of the pixels by weighting the lightness components of the pixels by the color saturation components of the pixels, compute mean values of the weighted lightness components, and adjust the brightness by converting the color image data to make the mean values desired values.

The "mean values of the weighted lightness components" can be mean values for all pixels, the mean values for only the center portion of the image or the mean values for a specific region among multiple regions into which the image has been divided.

In another aspect of the invention there is provided a system for adjusting image brightness comprising an adjuster having an adjustment unit for effecting a computation on color image data represented by a color signal composed of at least

three components to obtain pixel lightness components and adjusting brightness of an image represented by the color image data based on the lightness components, the system being characterized in that the adjuster further comprises an adjustment unit for adjusting the brightness of the image represented by the color image data based on color saturation components of the pixels.

In the system for adjusting image brightness according to the present invention, the adjuster preferably includes a weighted lightness component computing unit for computing weighted lightness components of the pixels by weighting the lightness components of the pixels by the color saturation components of the pixels, a mean value computing unit for computing mean values of the weighted lightness components, and a conversion unit for converting the color image data to make the mean values desired values.

The method and system for adjusting image brightness according to the invention adjust image brightness based on both the lightness components and the color saturation components of the color image data. As shown in Figure 2, a pixel's lightness comes closer to 18% reflectance with increasing color saturation. This adjustment of image brightness by also taking the value of the color saturation components into account therefore makes it possible to adjust the brightness of the image more accurately than is possible based solely on the lightness components.

Specifically, when the mean values of the lightness components are computed and adjustment is effected to make the mean values those of lightness components equivalent to 18% reflectance, the fact that the mean values are computed using the lightness components weighted by the color saturation components enables computation of mean values whose weighting is proportionally higher for pixels that are closer to $L^* = 50$, i.e., that are closer to 18% reflectance. Since the probability of the computed mean values being those of lightness components equivalent to 18% reflectance is therefore enhanced, the brightness of the image can be adjusted with high accuracy by converting the color image data to make the mean values desired values.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a block diagram of a system for adjusting image brightness that is an embodiment of the invention.

Figure 2 is a diagram showing the relationship between lightness and color saturation (CIE $L^*a^*b^*$ color representation system).

PREFERRED EMBODIMENT OF THE INVENTION

An embodiment of the invention will now be explained with reference to Figure 1.

Figure 1 is a block diagram of a system for adjusting image brightness that is an embodiment of the invention. As shown in this figure, this embodiment of the system for adjusting image brightness according to the invention is composed of a

data acquisition unit 1 for acquiring color digital image data S, a lightness computing unit 2 for computing the lightnesses L of the individual pixels of the digital image data S, a color saturation computing unit 3 for computing the color saturations C of the individual pixels of the digital image data S, a mean value computing unit 4 for computing the mean values Lm of the lightnesses L as explained later, and a converter 5 for converting the pixels of the digital image data S based on the mean values Lm to obtain converted output image data S'.

The data acquisition unit 1 is, for instance, an interface for connection with a digital camera, a card reader for reading data from a digital camera memory, a media drive for reading data from a CD-R or other such media, or a communication unit for receiving image data (none of which are specifically illustrated). In this embodiment, the color digital image data S are represented as a signal proportional to a power of the subject brilliance.

The operation of this embodiment will now be explained.

The color digital image data S acquired by the data acquisition unit 1 are sent to the lightness computing unit 2. The lightness computing unit 2 computes the lightnesses L of the individual pixels by Equation (1):

$$L = 0.1B + 0.6G + 0.3R \quad (1)$$

where

B, G, R: color signal components of pixels

The method of computing lightness L is not limited to Equation (1). Various other methods of computation can be used such as those of Equations (2) and (3):

$$L = \max (R, G, B) \tag{2}$$

$$L = \text{median} (R, G, B) \tag{3}$$

where

max (x, y, z): maximum value of x, y, z

median: (x, y, z): intermediate value of x, y and z

The digital image data S are also sent to the color saturation computing unit 3, which computes the color saturations C of the individual pixels by Equation (4):

$$C = \max (R, G, B)/\min (R, G, B) \tag{4}$$

where

min (x, y, z): minimum value of x, y, z

The computed lightnesses L and color saturations C are sent to the mean value computing unit 4, which computes weighted mean values Lm of the lightnesses of the pixels based on Equation (5):

$$Lm = \Sigma (L (x, y) \cdot C (x, y)/\Sigma C (x,y) \tag{5}$$

where

L (x, y): lightness L at pixel (x, y)

C (x, y): color saturation C at pixel (x, y)

Σ: sum for all pixels

When the hues are represented in the CIE $L^*a^*b^*$ color representation system as shown in Figure 2, the point at which $L^* = 50$ corresponds to 18% reflectance and color saturation C is highest in the vicinity of $L^* = 50$, i.e., in the vicinity of 18% reflectance. Therefore, the weighting of the lightnesses L by the color saturations C based on Equation (5) enables computation of mean values Lm whose weighting is proportionally higher for pixels that have larger color saturations C, i.e., that are closer to 18% reflectance. The computed mean values Lm therefore more appropriately represent the lightness at 18% reflectance.

The weighted mean values Lm computed by the mean value computing unit 4 are sent to the converter 5, which converts the brightnesses of the color signal components of the pixels based on Equation (6) below. Equation (6) converts the R, G, B color signal components of the pixels so that a pixel value of 18% reflectance becomes 118.

$$\begin{bmatrix} B' \\ G' \\ R' \end{bmatrix} = 118/Lm \cdot \begin{bmatrix} B \\ G \\ R \end{bmatrix} \qquad (6)$$

The thus-obtained digital image data S' are sent to a printer, monitor or other such reproduction means to be reproduced as a visible image.

Thus, in this embodiment of the invention, the lightnesses L are weighted by the color saturations C to compute the mean values Lm as shown by Equation (5), the weighted mean values Lm are made values to produce 18% reflectance, and the R, G, B color signal components are converted in accordance with Equation (6) to make the mean values Lm the desired value 118. The R, G, B signal components are thus converted to desired values using values that appropriately represent the lightnesses at 18% reflectance. The brightness of the image can therefore be adjusted with high accuracy. When digital image data S' obtained in accordance with Equation (6) were reproduced using a Frontier printer (product of Fuji Photo Film Co., Ltd.), images visually perceived to have good brightness were obtained.

The embodiment explained in the foregoing treats the digital image data S as a signal proportional to a power of the subject brilliance. However, when the digital image data S are acquired by reading developed film with a film scanner, for example, the digital image data S are represented as log values. In this case, the lightness L can be computed using and of Equations (1)-(3), but the color saturation C is computed using Equation (4'):

$$C = \max (R, G, B) - \min (R, G, B) \qquad (4')$$

On the other hand, the conversion of the R, G, B color signal components is effected based on Equation (7):

$$\begin{bmatrix} B' \\ G' \\ R' \end{bmatrix} = \begin{bmatrix} 118 - Lm \\ 118 - Lm \\ 118 - Lm \end{bmatrix} + \begin{bmatrix} B \\ G \\ R \end{bmatrix} \qquad (7)$$

Images were read into a Frontier scanner from exposed and developed Super G ACE400 color negative film and the recorded image data were converted in accordance with Equation (7). When the so-obtained digital image data S' were reproduced using a Frontier printer, prints visually perceived to have good brightness were obtained. (The scanner, film and printer were products of Fuji Photo Film Co., Ltd.)

The embodiment explained in the foregoing computes the mean values Lm for all pixels of the image represented by the digital image data S. The invention is not limited to this, however, and, for example, it is instead possible to divide the whole image into regions and compute the mean values for each region or to compute the mean values only for a region corresponding to the center portion of the whole image.

What is claimed is:

1. A method for adjusting image brightness comprising the steps of effecting a computation on color image data represented by a color signal composed of at least three components to obtain pixel lightness components and adjusting brightness of an image represented by the color image data based on the lightness components, the method being characterized in further comprising a step of adjusting the brightness of the image represented by the color image data based on color saturation components of the pixels.

2. A method for adjusting image brightness according to claim 1, wherein the step of adjusting the brightness of the image represented by the color image data based on color saturation components of the pixels is effected by computing weighted lightness components of the pixels by weighting the lightness components of the pixels by the color saturation components of the pixels, computing mean values of the weighted lightness components, and adjusting the brightness by converting the color image data to make the mean values desired values.

3. A system for adjusting image brightness comprising an adjuster having adjustment means for effecting a computation on color image data represented by a color signal composed of at least three components to obtain pixel lightness components and adjusting brightness of an image represented by the color image data based on the lightness components, the system being

characterized in that the adjuster further comprises adjustment means for adjusting the brightness of the image represented by the color image data based on color saturation components of the pixels.

4. A system for adjusting image brightness according to claim 3, wherein the adjuster includes weighted lightness component computing means for computing weighted lightness components of the pixels by weighting the lightness components of the pixels by the color saturation components of the pixels, mean value computing means for computing mean values of the weighted lightness components, and conversion means for converting the color image data to make the mean values desired values.

ABSTRACT OF THE DISCLOSURE

A method for adjusting image brightness is conducted by a system for adjusting image brightness. Digital image data acquired by a data acquisition unit are sent to a lightness computing unit and a color saturation computing unit that compute the lightness L and the color saturation C for every pixel and sends the computed values to a mean value computing unit. The mean value computing unit weights the lightness L by the color saturation C and computes weighted mean values Lm of the lightnesses L. A converter 5 converts the R, G, B color signal components constituting the digital image data S to make the weighted mean values Lm desired values.

FIG.1

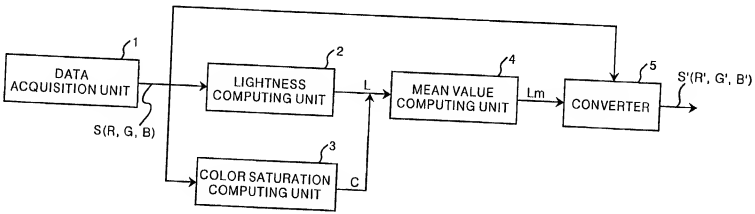
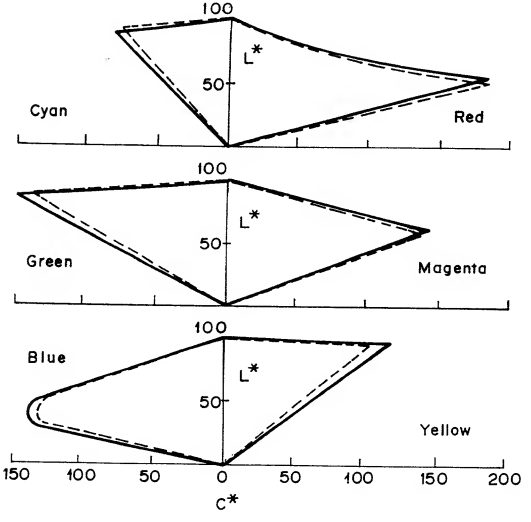


FIG. 2


100
L*
50
Cyan
Red
100
L*
50
Green
Magenta
100
Blue
L*
50
Yellow
150
100
50
0
50
100
150
200
C*

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Declaration and Power of Attorney For Patent Application

特許出願宣言書及び委任状

Japanese Language Declaration

日本語宣言書

下記の氏名の発明者として、私は以下の通り宣言します。

As a below named inventor, I hereby declare that:

私の住所、私書箱、国籍は下記の私の氏名の後に記載された通りです。

Takafumi Noguchi

My residence, post office address and citizenship are as stated next to my name. c/o Fuji Photo Film Co., Ltd. 210 Nakanuma, Minamiashigara-shi, Kanagawa-ken, Japan

下記の名称の発明に関して請求範囲に記載され、特許出願している発明内容について、私が最初かつ唯一の発明者（下記の氏名が一つの場合）もしくは最初かつ共同発明者であると（下記の名称が複数の場合）信じています。

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

"METHOD AND SYSTEM FOR ADJUSTING IMAGE BRIGHTNESS"

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the specification of which is attached hereto unless the following box is checked:

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☐ was filed on _____
as United States Application Number or
PCT International Application Number
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_____ (if applicable).

私は、特許請求範囲を含む上記訂正後の明細書を検討し、内容を理解していることをここに表明します。

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

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Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Japanese Language Declaration
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Prior Foreign Application(s)
外国での先行出願

(Number) (番号)	(Country) (国名)	(Day/Month/Year Filed) (出願年月日)	Priority Not Claimed 優先権主張なし
(patent)66784/1998	Japan	17/03/1998	☐
			☐

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I hereby claim the benefit under Title 35, United States Code, Section 120 of any United States application(s), or 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of Title 35, United States Code Section 112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of application.

(Application No.) (出願番号)	(Filing Date) (出願日)	(Status: Patented, Pending, Abandoned) (現況：特許許可済、係属中、放棄済)

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委任状： 私は下記の発明者として、本出願に関する一切の手続きを米特許商標局に対して遂行する弁理士または代理人として、下記の者を指名いたします。(弁護士、または代理人の氏名及び登録番号を明記のこと)

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith *(list name and registration number)*

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第二共同発明者		Full name of second joint inventor, if any
第二共同発明者	日付	Second inventor's signature / Date
住所		Residence
国籍		Citizenship
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(第三以降の共同発明者についても同様に記載し、署名をすること)

(Supply similar information and signature for third and subsequent joint inventors.)